The potential for biotechnology in sustaining agriculture – an international perspective

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Abstract

Sustainability in agriculture means different things to different people. Generally in the context of the industrialized world, the focus is often on excess production; farm intensification and environmental pollution; from high inputs of fertilizers and pesticides. However, in developing countries the issues impinging on sustainable agriculture are different and generally of a more wide-ranging nature. The overriding concerns are more usually declining soil fertility; inputs of crop nutrients and crop protectants that are unsustainably low; the (seemingly more frequent) impacts of biotic stress, such as drought, heat and flooding; lack of water; and the ravages of a changing vanguard of pests and diseases. Added to these biophysical elements are other challenges to sustainability – lack of infrastructure (transport/markets); inappropriate and/or inconsistent agricultural policies and the often undesirable impacts of the agricultural trade policies of others.

One definition of sustainable agriculture that is economically viable; environmentally sound; socially appropriate/acceptable; and politically supportable. Whilst this framework embraces sustainable agriculture in all countries the issues for developing countries are, as described above, generally different to those in Australia or the US, or Europe. It is therefore extremely important that when considering the contribution that life sciences and biotechnology can make to sustainable agriculture globally we remember this important context as not all of the problems are amenable to solely technological solutions. Of those that are, it is my opinion that soil fertility decline; crop tolerance to abiotic stresses – particularly drought and heat; and crop tolerance/resistance to pests and diseases are of the highest priority. A close second order of priority is enhancement of the nutritional (and sometimes industrial) value of crop and livestock products. How can life sciences and biotechnology contribute?

- **Declining soil fertility** – is perhaps the single biggest challenge to sustainable agriculture in developing countries. Unless it is rectified the prospects for meeting the increasing demands for food production and the desired levels of income generation for the future are very bleak. There is no 'magic bullet' to address this issue. Better rotations; inorganic and organic fertilizers and reduced tillage systems are all important to a greater or lesser extent depending on location. However the need for smallholder farmers to produce more food from a static or shrinking farm area inevitably means soil fertility is spiraling down. If the farmer needs to plant the whole farm to produce – the say 2 t of maize s/he needs for family survival – then the whole farm will be planted to maize, year in, year out, and soil fertility declines. Therefore any intervention that allows the farmer to produce that needed maize off only 50% of the farm area allows for better rotations, diversification, fallows, cash crops which all contribute to enhanced soil fertility. Those intervention include better crop varieties resulting from modern plant breeding. New varieties have the advantage in that new characters/technology 'embedded' in the seed are easy to adopt.
- **Stress tolerance in crops** – has always been important in agriculture; however, it has gained even greater importance in developing countries during the past decade or so. Climatic variability has increased and with it the depredations of drought, heat, waterlogging and new, or exacerbated, pest and diseases. Clearly biotechnology has a major role to play in producing crops with greatly enhanced stress tolerance. Excellent breakthroughs in both maize and wheat illustrate this potential for both abiotic and biotic stresses. An overriding related trait of paramount importance to sustainable agriculture now and in the foreseeable future, is water-use efficiency. The competition for water for agriculture is of critical importance and farming-systems and crop varieties that have enhanced water-use efficiency are essential. New technologies have a key role to play in achieving better water use either in irrigated or rainfed systems.
- **'Biofortification'** – is a recently invented term to describe the nutrient enrichment of basic food crops through modern plant breeding, both traditional and molecular. Whilst many would argue

that dietary diversification is the best way to ensure an adequate intake of both macro and micronutrients, the grim reality is that a significant portion of the developing world's population relies largely on one or more of the major cereals (rice, wheat, maize) for their nutrition. As a result deficiencies of essential micronutrients and vitamins are endemic in Asia, Sub-Saharan Africa and Latin America. Studies have shown that modern plant breeding is one of the cheapest, most effective and sustainable ways of supplying these needed nutrients through enrichment of staple food grains. Biofortification is not a panacea in itself but a very important complement to dietary variety and to supplementation.

Given the overriding importance of agriculture for the large majority of people in the developing world, for both food production and income generation, it is essential that all appropriate options are pursued to ensure its sustainability. If we do not take this action the consequences will be catastrophic. Biotechnology can help to ensure more productive, profitable and sustainable agriculture globally but it is only one component of the integrated approach required.